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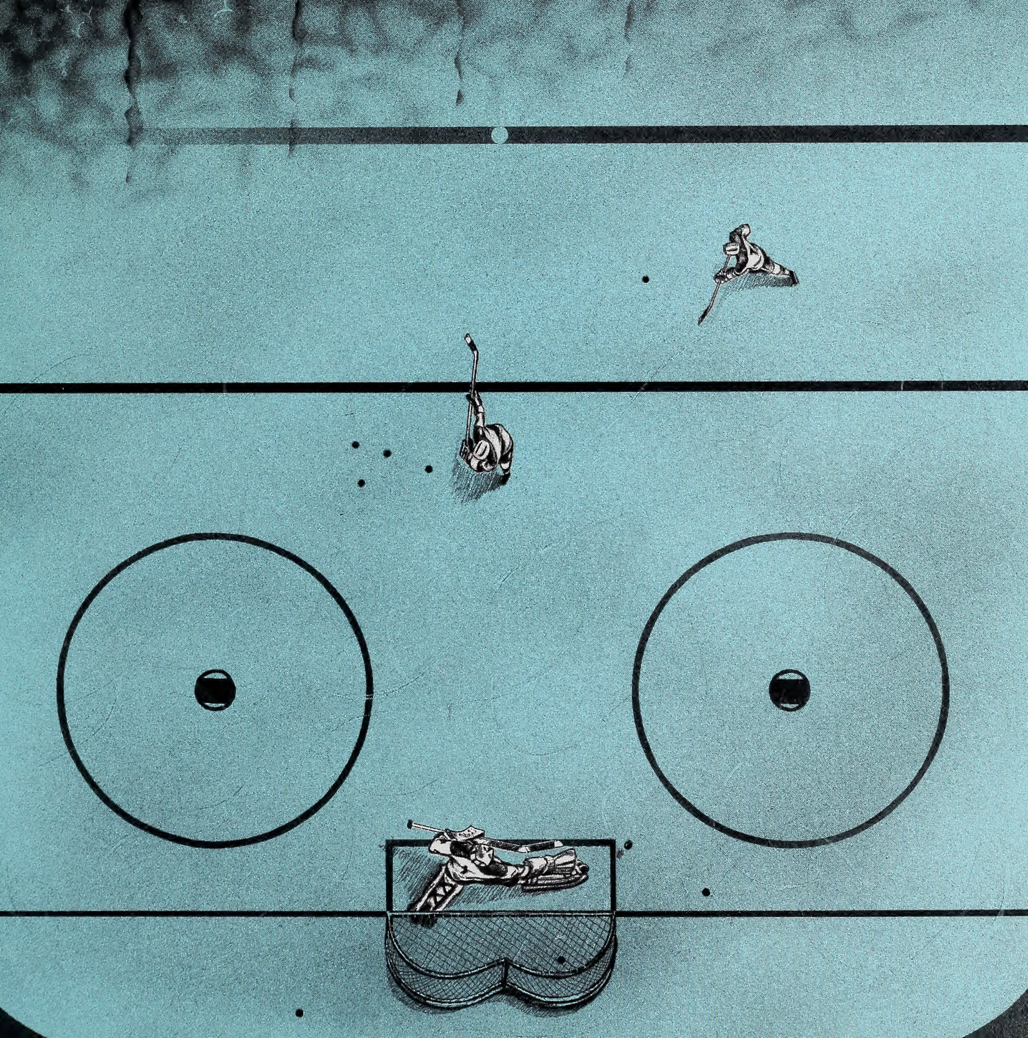
Some Energy Conservation Concepts for Recreational Facilities

Projects supported in part by the Alberta/Canada Energy Resources Research Fund



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1990
Edmonton

Alberta
ENERGY
Research and Technology Branch

Pub. No. I/308

ISBN 0-86499-668-3

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Foreword

Since 1976, numerous projects have been initiated in Alberta by industry and by academic research institutions which are aimed at better utilization of Alberta's energy resources.

These research, development and demonstration efforts were funded by the Alberta/Canada Energy Resources Research Fund (A/CERRF), which was established as a result of the 1974 agreement on oil prices between the federal government and the producing provinces.

Responsibility for applying and administering the fund rests with the A/CERRF Committee, made up of senior Alberta and federal government officials.

A/CERRF program priorities have focused on coal, energy conservation and renewable energy and conventional energy resources. Administration for the program is provided by staff within the Research and Technology Branch of Alberta Energy.

In order to make research results available to industry and others who can use the information, highlights of studies are reported in a series of technology transfer booklets. For more information about other publications in the series, please refer to page 10.

Some Energy Conservation Concepts for Recreational Facilities

Virtually every community in Alberta, whether a major city or a small village, has an indoor recreational facility of some kind, such as an ice arena, curling rink, swimming pool or combinations of these in multi-use complexes.

In operating these facilities, substantial quantities of energy are consumed to maintain pool water temperature at a constant level, provide heat during the winter or prevent ice surfaces from melting. In many instances, this energy consumption is inadequately controlled, resulting in unnecessary expense, inconvenience and discomfort to patrons. In some cases, opportunities exist to recover and re-use waste heat, but this is rarely done. This situation is changing as new or improved energy-conserving technologies become available and their effectiveness under Alberta's climatic conditions is measured.

The following are examples of situations that lent themselves to studies of the potential for energy conservation. These projects were supported by the Alberta/Canada Energy Resources Research Fund (A/CERRF) between 1983 and 1989.

Waste Heat Recovery in a Multi-use Facility

In some Canadian ice arenas, the waste heat produced by the refrigeration plant is recovered and used to heat the facility's tap water or to satisfy some of the space-heating requirements. This often requires some form of thermal storage system because the demand for heat does not necessarily coincide with its availability. In a multi-use facility, where both ice rinks and swimming pools may be present, waste heat recovered from the ice rink refrigeration equipment can be used to heat the swimming pool water. This can reduce or eliminate the need to purchase fuel to fire a water boiler, and the pool water itself serves as a thermal storage system.

In 1985, Kasten Eadie Engineering Ltd. of Edmonton investigated the feasibility of using a waste heat recovery system at the Triplex Arena in the town of Okotoks, Alberta. This facility comprises three artificial ice rinks, a swimming pool and a whirlpool. It also uses 15 electric heaters for space heating that are located throughout the building.

It was calculated that 1 530 gigajoules of high-grade heat are available annually from the refrigeration equipment, assuming two of the rinks operate six months of the year, while the third rink is used year-round. If this high-grade heat were used to heat water for the pools, it could eliminate the need to purchase natural gas valued at approximately $5 400.

It was also calculated that installation of a heat-recovery system would cost $19 000. Therefore, a payback period of 3.5 years was expected on equipment that should last 25 years. Even with a funding offer from A/CERRF, amounting to 46 per cent of the total capital costs, the Town of Okotoks decided not to proceed with the project because of budget constraints. Despite this set-back, however, the potential for energy and cost savings is substantial. A simple calculation showed that although waste heat valued at $2.8 million a year is being produced collectively by the 560 artificial ice rinks in Alberta, it is not recovered and re-used.

Demonstration of Low Emissivity Ceilings

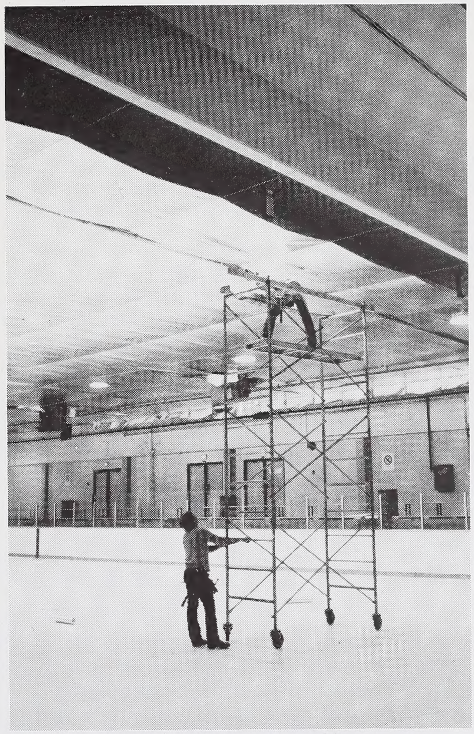
Studies have shown that transfer of heat by radiating energy from the warm ceiling of an indoor ice arena to the cold ice surface can account for as much as 35 per cent of the daily load on the arena's refrigeration system. As has been demonstrated in some Ontario and Quebec arenas, installation of an aluminized ceiling material, having a radiative emissivity of four to five per cent (versus 85 to 95 per cent for wood) above the ice surface, can reduce refrigeration energy requirements by as much as 33 per cent.

To determine whether similar results were possible in Alberta's climate, a demonstration project was initiated in 1985 by Sunton Engineering Ltd. of Edmonton.

Permission was granted by the operators of the Londonderry Arena in Edmonton and the Civic Centre Arena in Medicine Hat to allow demonstration of Aluma-Zorb low emissivity ceiling material. This product comprises a mottled, reflective aluminum foil coating over a vinyl backing reinforced with a fibreglass scrim.

At the Londonderry Arena, where ice is present year-round, approximately 1 950 m^2 (20 990 sq. ft.) of Aluma-Zorb were suspended 6 m (20 ft.) above the 26 m x 59 m (85 ft. x 194 ft.) ice surface and some of the spectator area. Parallel rows of plastic-coated aircraft wire, fastened at the ends to concrete walls and tightened with turn-buckles, were used to support 1.2 m- (4 ft.-) wide strips of Aluma-Zorb directly beneath the existing, flat, concrete truss roof. Holes were cut in the Aluma-Zorb to accommodate existing lamp sockets and bulbs.

Installation at the Medicine Hat Civic Centre Arena, where ice is present 10 months of the year, was somewhat more complicated. This complication was caused by a curved roof and a higher ceiling, which was 14 m (47 ft.) above the ice surface and required the use of a hydraulic man-lift, as opposed to simple scaffolding at the Londonderry Arena. Also, sound baffles suspended by wires from the ceiling had to be removed before the low emissivity ceiling could be installed.

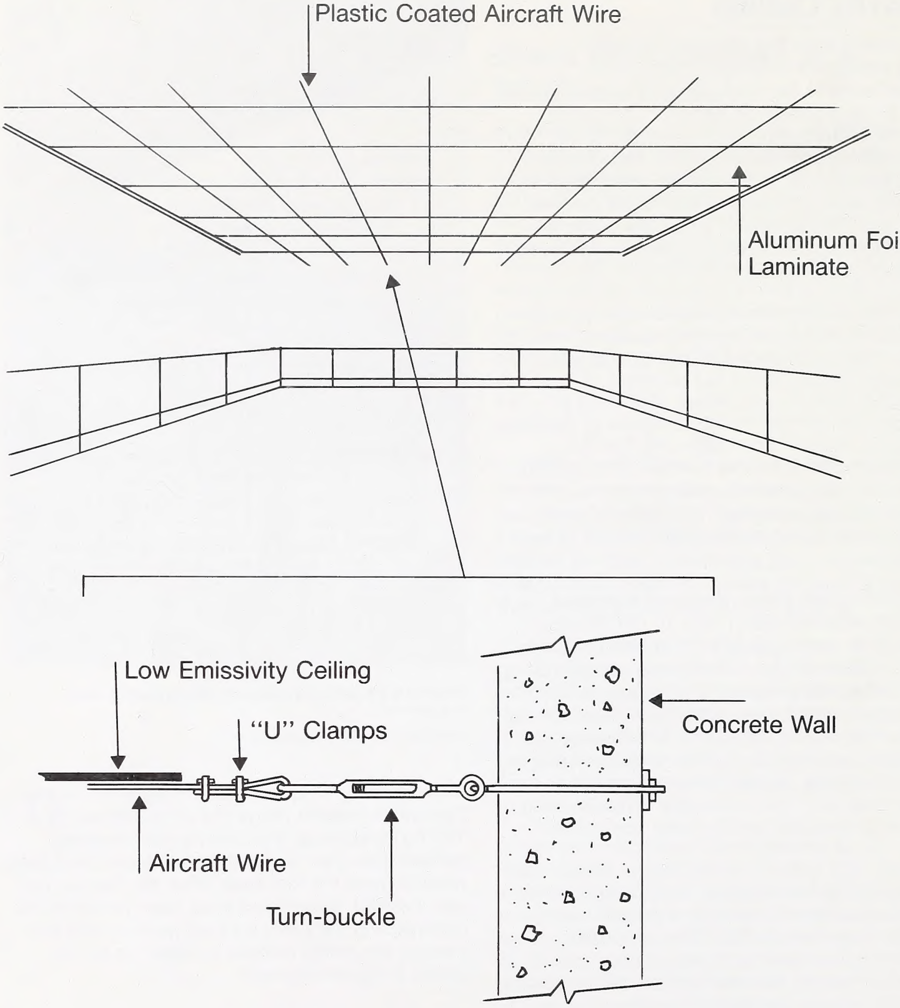


Installing a low emissivity ceiling at the Londonderry Arena in Edmonton.

(Photo courtesy: Sunton Engineering Ltd.)

Approximately 1 858 m^2 (20 000 sq. ft.) of Aluma-Zorb were installed above the 26 m x 60 m (85 ft. x 197 ft.) ice surface. The material was attached beneath the upper member of open-web steel joists which formed the roof truss. After the Aluma-Zorb was installed, finger-sized holes were poked in the material, and the baffle support wires were pulled through the ceiling material to allow the sound baffles to be re-attached.

Low Emissivity Ceilings: Installation Details



(Source: *Demonstration of Low Emissivity Ceilings in Arenas — Phase II Report,* Sunton Engineering Ltd., September 1986)

Initial Observations

Soon after the low emissivity ceiling was installed at the Londonderry Arena, the ice temperature controller setting was raised to -7°C (20°F) to take advantage of the immediate reduction in the radiant heat load and reduced compressor energy demand.

In this arena, the ice is removed once a year to permit scheduled maintenance of the equipment. In the past, formation of a new ice slab after maintenance was completed usually required 48 to 72 hours, but after installation of Aluma-Zorb, ice slab formation was accomplished in 19 hours. Previously, it was also necessary to spray the condenser with water to keep it cool when the ice surface was replaced in hot weather. After the new ceiling was installed, spraying was not required.

This arena uses energy-saving lamps capable of providing variable light levels at different power settings. After the Aluma-Zorb was installed, it was found that a 27 per cent reduction in the power setting could be made without altering the light level.

At the Civic Centre Arena, the temperature controller was re-set to achieve -4°C (24°F) on the brine supply line and -3°C (26°F) on the brine return line. Previously, temperature settings had been as low as -11°C (12°F). In the past, three compressors were needed to maintain desired ice conditions during hot weather, but only one was needed after the Aluma-Zorb ceiling was installed.

Although the Civic Centre Arena was not equipped with energy-saving lighting fixtures, the light was observed to be brighter after the new ceiling was installed.

Monitoring and Results

Comparisons were made of energy consumption (as represented by the compressor operation time) for one year before and after the two low emissivity ceilings were installed.

In the case of the Londonderry Arena, incomplete records of the "before" period made it necessary to use a second, identical arena (Grand Trunk) as the basis for comparison, making allowances for the fact that the other arena, unlike Londonderry, was not equipped with an energy-saving lighting system.

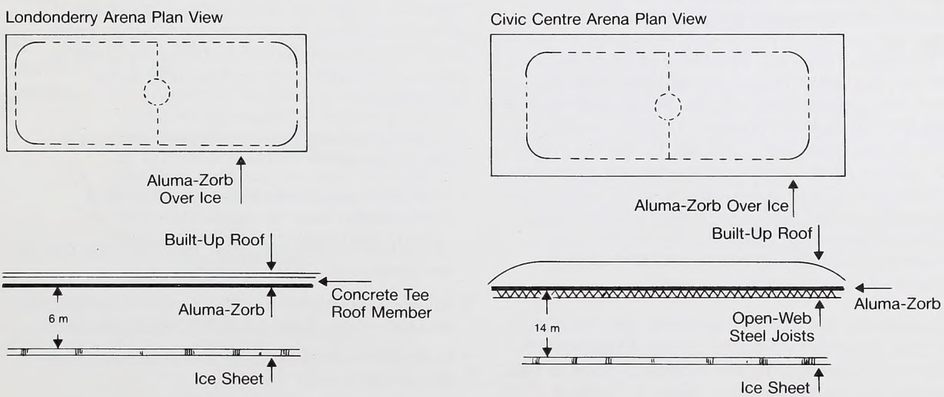
Compressor Operation Records

	Hours		Per Cent
Arena	1985/86	1986/87	Change
Londonderry	-	6 509	-40.6*
Grand Trunk	11 204	10 964	-2.1
Civic Centre	9 441	6 838	-27.6

*Compared with 1986/87 records at Grand Trunk Arena.

In comparing compressor operation records of the Grand Trunk Arena for 1985/86 and 1986/87, it was concluded that a 2.1 per cent difference from one year to the next was sufficient justification for assuming that compressor operation time was fairly constant. It was also independent of changes

Positioning of Aluma-Zorb Ceilings Relative to Existing Roofs and Ice Surface



(Source: *Demonstration of Low Emissivity Ceilings in Arenas – Phase II Report*, Sunton Engineering Ltd., September 1986)

in the severity of the weather, as indicated by degree-day records. Because it had been decided that the Grand Trunk Arena probably consumed energy in a manner similar to the Londonderry Arena before the Aluma-Zorb ceiling was installed, the 1986/87 compressor operation records from the Londonderry Arena were directly compared with the Grand Trunk records for the same year.

Consequently, it was concluded that the low emissivity ceiling was largely responsible for causing a reduction of 4 455 hours in the compressor operation time. At the prevailing costs of electricity in Edmonton, this amounted to an annual savings of $14 482. When compared with a cost of $27 509 to install the ceiling, a simple payback period of 1.9 years was calculated.

It was acknowledged, however, that some portion of the savings must be attributed to the use of energy-saving lighting in the Londonderry Arena since there was less heat produced at lower power settings.

At the Civic Centre Arena, a 27.6 per cent reduction in compressor operation time was measured. This was equivalent to an annual savings of $3 573, or a simple payback period of 8.3 years for capital costs of $29 500.

Conclusions

In examining the differences between the results for the two arenas, the researchers concluded that several factors must be considered when estimating the potential economic effect of using low emissivity ceilings. They are as follows:

- length of operating season;
- cost of electricity;
- type and capacity of refrigeration plant; and
- whether energy-saving lighting is used.

For example, savings at the Civic Centre Arena were not as impressive as those at the Londonderry Arena because electricity is only half as expensive in Medicine Hat as in Edmonton, and ice is present in the Civic Centre Arena for only 10 months of the year, versus 12 at Londonderry. Also, the use of a conventional lighting system at the Civic Centre Arena made it impossible to reduce the heat load on the compressors caused by the lamps, even though the reflectivity of the Aluma-Zorb ceiling allows lower light levels to be used.

Subsequently, the City of Edmonton was awarded the C.N. Densmore Award for Energy Management, which was presented by the Alberta Chapter of the Canadian Public Works Association in October 1988, in recognition of the energy savings that resulted after the low emissivity ceiling was installed at the Londonderry Arena. Since this installation was completed, low emissivity ceilings have been installed in several other Edmonton arenas, with an average payback period of 1.5 years. In these arenas, it was found that higher ice temperatures, made possible by the low emissivity ceilings, caused higher air temperatures within the arenas and lower natural gas usage for heating.

Finally, it was concluded that the operating time for refrigeration systems in most Alberta arenas could be reduced by 25 to 30 per cent if low emissivity ceilings were used. However, the particular circumstances of each arena would dictate the magnitude of cost savings and the length of the payback period.

Energy Analysis and Retrofit of Public Swimming Pools

Beginning in 1984, the IBI Group of Calgary performed an energy inventory of all 11 indoor public swimming pools operated by the City of Calgary. To determine the potential advantages that retrofitting might offer, especially considering that each pool annually consumes natural gas costing $29 000 and electricity valued at $22 000, two retrofit strategies were proposed for a pool considered to be representative of the group.

These strategies were based on a detailed energy audit of the "typical" pool and analysis of 40 individual retrofit options.

In Strategy I, which was implemented at the Renfrew Pool in 1985, it was assumed that the existing building shell would not be upgraded. It focused on control of intake air and exhaust air in response to outdoor air conditions and desired indoor conditions. It included control of humidity levels to avoid condensation inside the building, and also featured control of the pool water temperature.

The principal components of the control strategy were as follows:

- to operate supply air and exhaust air fans continuously;
- to control the gas-fired duct heater to maintain air temperature at 29.5°C (85°F);
- to use a humidistat to control outside air dampers and the return dampers in the supply air unit;
- to control relative humidity to a maximum level of 60 per cent; and
- to maintain a slight negative pressure in the pool area.

To provide the desired degree of control over these elements, a Johnson Controls DSC-8500 microprocessor-based programmable controller was installed, along with the following:

- temperature sensors within various zones of the pool area and the pool itself; and
- relative humidity sensors in the pool area, the exterior cavity wall of the swimming pool and outside the building.

Readings from these sensors were recorded for one year after the control system was installed. Records were kept of natural gas consumption.

Examples of Retrofit Options and Analysis*

Measure:	Increase relative humidity in pool area to 60 per cent from 50 per cent.
Savings:	3 126 GJ of natural gas per year. Equivalent to $7 659.
Cost:	None
Payback:	Immediate
Comments:	The selected conditions for the pool area are: Water Temp. = 26.7°C (80°F) Deck Dry Bulb Temp. = 29.5°C (85.1°F) Deck Relative Humidity = 50 per cent Maintaining the water and air dry bulb temperatures, when relative humidity is raised to 60 per cent will result in lower demand for outside air to reduce the indoor humidity. Also, less pool water heating will be required to compensate for evaporative losses.

Measure:	Reset humidistat relative humidity according to outdoor temperature.
Savings:	1 915 GJ of natural gas per year. Equivalent to $4 691.
Cost:	$1 000.00
Payback:	0.2 year
Comments:	As the outdoor temperature rises, higher relative humidities can be tolerated in the pool area without causing condensation on the exterior envelope. During unoccupied periods in particular, the relative humidity in the space could be increased without detrimental effects at higher outdoor temperatures. The proposed reset control would fulfill this condition.

*For Killarney Pool

(Source: *Killarney Indoor Swimming Pool Energy Audit and Retrofit Study,* IBI Group, December 1984)

Results

Although the controller set-points for air temperature and pool temperature were eventually lowered by the Renfrew Pool staff below the recommended values (in response to complaints of discomfort by pool users), energy savings were still significant. When compared with natural gas consumption during the year before the control system was installed, it was calculated that annual energy savings amounted to 4 110 GJ, estimated to be worth $10 700. This resulted in a payback period of 2.2 years, based on capital costs of $23 590. While engineering costs are not included in this calculation (and would have extended the payback period), it would be necessary to conduct an energy audit and analysis, as well as design a program for each building to be retrofitted with similar control schemes.

Swimming Pool Dehumidification Demonstration

Control of air humidity inside a building housing a public swimming pool is important because it is one of the environmental conditions that can make the difference between patrons feeling comfortable or uncomfortable when they are out of the water. In most facilities of this sort, dehumidification of air in the general area of the pool is accomplished by using conventional ventilation systems to bring outside air into the building. In five of 60 "commercial" swimming pools in Alberta, however, heat pump dehumidification systems have been installed in recent years because they are said to be more energy-efficient.

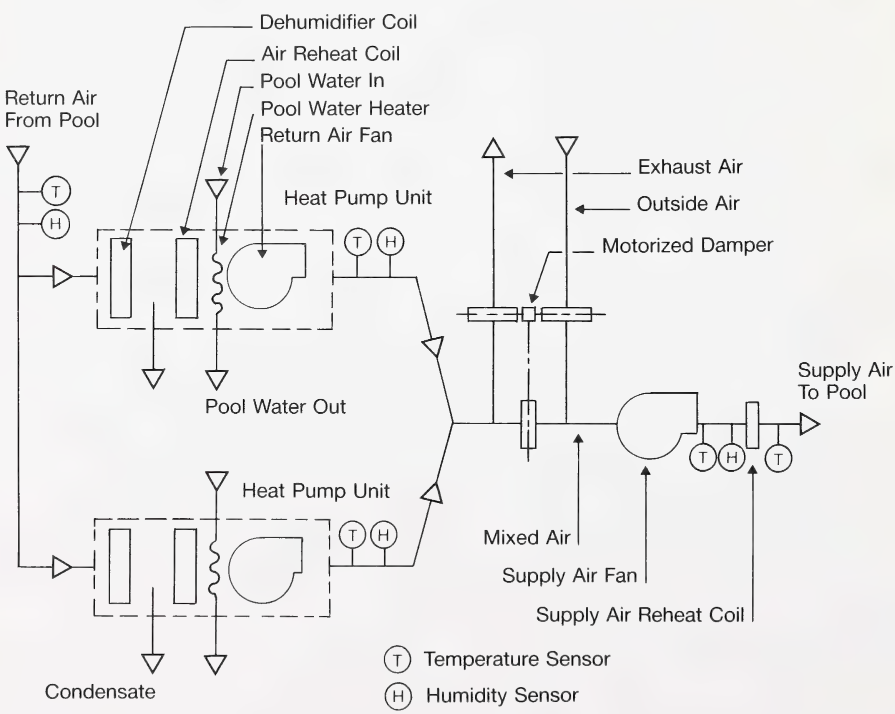
One such installation is in the Max Bell Regional Aquatic Centre at the University of Lethbridge. This facility has one of the largest indoor pools in Alberta. It uses both a heat pump dehumidifier and a conventional outdoor air intake and exhaust system. Thus, Klass Mechanical Enterprises Ltd. of Calgary, in association with Lamb McManus Associates Ltd., also of Calgary, undertook a study of both systems to determine which was more energy-efficient and incurred lower energy costs under particular conditions. Each system was monitored individually and evaluated for its ability to conserve energy and reduce energy costs.

From an initial review of heat pump technology, it was concluded that such devices have proven to be energy-efficient and have been cost-effective in other Canadian provinces that experience higher energy costs than Alberta. Preliminary indications suggested that heat pump dehumidifiers could save money in Alberta if used in high-use pools operated by municipalities, universities, hotels/motels and residential complexes. For example, at one pool in Calgary where heat pump and ventilation types of dehumidifiers are used, energy savings of $200 a month were achieved by operating the heat pump unit whenever the outside temperature fell below 18°C (64.4°F).

Consequently, a detailed investigation was made of the two heat pump dehumidification systems (Dryotrons) and the single, variable air intake and exhaust system used at the Max Bell Regional Aquatic Centre. Because each of these systems can be operated separately to remove moisture from the swimming pool enclosure, they were run and monitored under similar indoor conditions between September 16, 1987 and March 8, 1988. The following were monitored:

- pool space dry bulb temperature and relative humidity;
- swimming pool water temperature;
- outdoor air dry bulb temperature and relative humidity;
- air handling unit mixed air temperature;
- pool supply air and return air temperature;
- pool return air relative humidity;
- mixed air damper position and temperature control set-point;
- energy consumed by the building and pool water heating systems;
- electrical energy used by the two heat pump compressors; and

Schematic of Pool Air system



(Source: *Swimming Pool Dehumidification Demonstration at Max Bell Regional Aquatic Centre, Final Project Report,* Lamb McManus Associates Ltd., 1989)

- the volume of condensate produced by the heat pump units.

It was found that both systems were capable of maintaining constant air and pool water temperatures and relative humidity in the pool space. At ambient temperatures below 9.5°C (49°F), the heat pump system required less total energy than the conventional ventilation system, but the energy it required (electrical) was more expensive than the purchased energy (natural gas) it displaced. Consequently, the ventilation system experienced lower energy costs.

It was suggested that sizing the heat pump dehumidifiers to match the load was possible, and such devices would not be more expensive to purchase than conventional systems. Thus, in locations having lower electricity costs and higher natural gas costs than Alberta, heat pumps would be less costly to operate than conventional systems. In Alberta, it is possible to operate either system for similar energy costs.

Contacts

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Pub. No. I/308
ISBN 0-86499-668-3